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EVALUATION OF TECHNIQUES FOR ASPHALTIC PAVEMENT LONGITUDINAL JOINT CONSTRUCTION

FINAL REPORT

WISCONSIN DEPARTMENT OF TRANSPORTATION

TECHNOLOGY ADVANCEMENT

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16. Abstract

This study was initiated in response to a report prepared by the National Center for Asphalt Technology (NCAT) and Auburn University ("Evaluation of Longitudinal Joint Construction Techniques for Asphalt Pavement"). The NCAT/Auburn study evaluated eight asphaltic pavement longitudinal joint techniques on test sections in both Michigan and Wisconsin. Initial results found the wedge joint to be one of the best performing joints, achieving the highest density, in the Michigan project. However, the wedge joint did not perform nearly as well in the Wisconsin project. This was likely due to Wisconsin's inexperience with the wedge joint and lack of proper equipment.

In 1993, the Wisconsin Department of Transportation (WisDOT), in partnership with the Wisconsin Asphalt Pavement Association (WAPA) and Mathy Construction Company, the participating contractor, organized this study to accompany the NCAT/Auburn study. This study evaluates eight longitudinal joint construction techniques with an emphasis on the wedge joint. The test sections consist of the conventional method, wedge joint method with truck tire rolling, wedge joint method without rolling, wedge joint method with steel side roller wheel, wedge joint method with rubber side roller wheel, wedge joint method with tag-along roller, cut joint method, and conventional joint method with Bomag edge constraint device.

The test sections extend from Boscobel to Soldiers Grove on United States Highway (USH) 61, a two-lane rural highway in Crawford County. The relative performance of each joint construction technique is derived from density results and performance rankings based on the amount of longitudinal cracking at the centerline joint. The density results and the ten-year performance evaluation both show that the wedge joint constructed by steel side roller wheel and the wedge joint constructed by tag-along roller perform the best. However, based on worker comments, it is much easier to construct the wedge joint with the steel side roller wheel than with the tag-along roller.

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EVALUATION OF TECHNIQUES FOR ASPHALTIC PAVEMENT LONGITUDINAL JOINT CONSTRUCTION

FINAL REPORT

REPORT NUMBER: WI-08-03
WisDOT Highway Research Study # 93-08

by

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for

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INTRODUCTION

The hot mix asphalt (HMA) paving practices in many states, including Wisconsin, can lead to an undesirable density variation at the centerline joint. During the asphalt paving process, the HMA is typically placed and compacted in one lane at a time so traffic does not have to be detoured. The first lane paved will be referred to as the cold lane because the hot mix asphalt in this lane cools off by the time the second, or hot, lane is paved. Since nothing confines the inside edge of the cold lane during paving, it tends to have a lower density. The hot lane tends to have a higher density, since the cold lane confines its edge during the paving process (Kandhal & Rao, 1994). The density of the hot lane is increased further during the compaction process. During the first roller pass of the hot lane compaction, the roller rides entirely on the hot lane, a few inches away from the longitudinal centerline joint. On the return pass, the roller continues to ride on the hot lane and slightly overlaps onto the cold lane, pressing the hot lane tightly against the cold lane. The density variation at the joint between the hot and cold lanes reduces the tensile strength of the pavement and leads to both longitudinal cracking and raveling of the pavement along the longitudinal joint. These distresses could contribute to even further deterioration of the roadway because they allow moisture to penetrate into the asphaltic pavement.

BACKGROUND

In 1992, the National Center for Asphalt Technology (NCAT) and Auburn University initiated a study to evaluate longitudinal joint construction techniques for asphalt pavement. The research evaluated eight different longitudinal joint construction techniques on test sections in both Michigan and Wisconsin (Kandhal & Rao, 1994):

1. Rolling Technique A (conventional overlapping procedure, rolling from hot side)
2. Rolling Technique B (conventional overlapping procedure, rolling from cold side)
3. Rolling Technique C (conventional overlapping procedure, rolling from hot side 6 inches away from joint)
4. Wedge Joint Without Tack Coat
5. Wedge Joint With Tack Coat
6. Restrained Edge Compaction

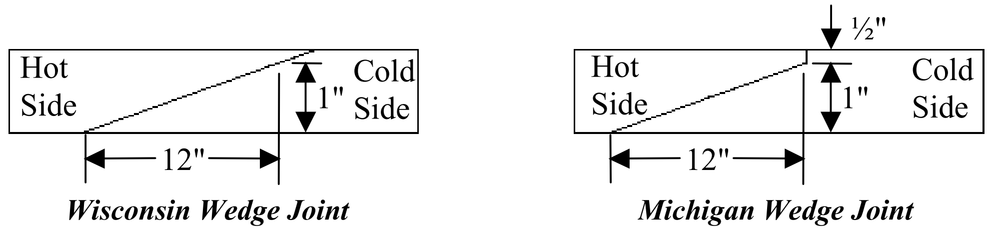
7. Cutting Wheel
8. AW-2R Joint Maker (automated joint construction)

The study was of particular interest to the Wisconsin Department of Transportation (WisDOT) because the longitudinal joints in asphaltic pavements in Wisconsin had a tendency to crack and ravel. In fact, WisDOT considered the longitudinal joint to be the most inadequate element of Wisconsin's asphaltic pavements (WisDOT, 1993).

On March 8, 1993, the HMA Policies and Issues Committee met and reviewed a draft of the NCAT/Auburn Interim Report, "Evaluation of Various Longitudinal Joint Construction Techniques" (Kandhal & Rao, 1993). The research found that, although the wedge joint test sections achieved the highest densities in the Michigan project, they did not perform well in the Wisconsin project. The wedge joint in Wisconsin was constructed differently than it was constructed in Michigan, likely due to the lack of experience with the wedge joint in Wisconsin. Unlike the Michigan wedge joint, the Wisconsin wedge joint did not include a vertical offset of ½ inch at the top of the wedge (see Figure 1 on the following page) and the face of the wedge was not compacted. The HMA Policies and Issues Committee members concluded that the Wisconsin test sections of the NCAT/Auburn study showed a need for better joint compaction and better equipment to produce the tapered wedge joints (WisDOT, 1993). An additional study, WisDOT Research Study #93-08, was organized to evaluate longitudinal joint construction techniques with a strong focus on wedge joint construction. This study would not only determine the best longitudinal joint construction technique, but also, by using the Michigan wedge joint design[1], it would determine if the wedge joint constructed in Wisconsin could perform as well as the wedge joint constructed in Michigan.

[1] The only variation in construction between the two studies is in the compaction techniques. The WisDOT study used vibratory roller compaction, whereas the NCAT/Auburn study used rolling in the static mode (WisDOT, 1993).

Figure 1. Wedge Joint Construction in Wisconsin and Michigan (Not to Scale)



Both the Wisconsin (left) and the Michigan (right) wedge joints have a 1:12 taper, but the wedge joint on the Wisconsin project did not include a ½-inch notch at the top of the wedge.

This is the final report for WisDOT Research Study #93-08, which was initiated in 1993 by WisDOT, in partnership with the Wisconsin Asphaltic Pavement Association (WAPA) and Mathy Construction Company, the participating contractor.

PROJECT OVERVIEW

This study compares the performance of eight different types of centerline longitudinal joint construction techniques:

1. Conventional Method – ***Similar to NCAT/Auburn "Rolling Technique C"***
2. Wedge Joint Method
   (rolling is with the hauling truck tires)
3. Wedge Joint Method
   (without truck tire rolling)
4. Wedge Joint Method
   (steel side roller wheel installed on side of steel-wheeled roller)
5. Wedge Joint Method
   (rubber side roller wheel installed on side of rubber-tired roller)
6. Wedge Joint Method
   (rolling is with tag-along roller installed on the HMA paver)

   Similar to NCAT/ Auburn "Wedge Joint With Tack Coat" (items 2–6)
7. Cut Joint Method (cutting wheel on a roller cuts away about two inches of mix) – ***Similar to NCAT/Auburn "Cutting Wheel"***
8. Conventional Joint With Bomag Edge Constraint Device (installed on steel-wheeled roller) – ***Similar to NCAT/Auburn "Restrained Edge Compaction"***

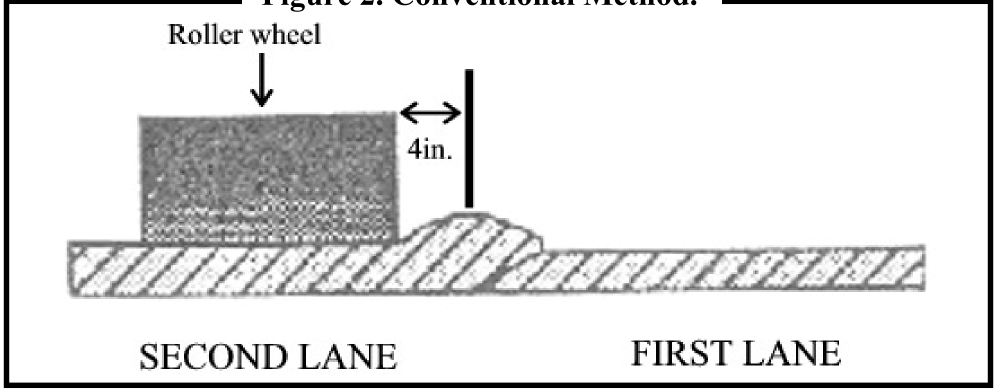
The relative performance of each construction technique is evaluated in this study to establish the preferred method(s) of joint construction. Performance evaluations are based on density results and an overall performance ranking based on amount of longitudinal joint cracking.

JOINT DESCRIPTIONS

Conventional Method -

The conventional method is the industry standard butt-type joint and is used as the control in this study (WisDOT, 1993). After the first (cold) lane is placed and a tack coat is applied at the edge of the lane, the longitudinal joint is constructed by slightly overlapping the second (hot) lane over the first lane. The first pass with the compacting device runs 4-6 inches away from the joint on the hot side, pushing the HMA laterally towards the joint (see Figure 2 below). The second pass of the compaction process overlaps onto the cold side by approximately 6 inches, pinching the material into the joint. This technique achieves a high density at the joint, reducing the density gradient across the joint (Kandhal & Rao, 1994).

Figure 2. Conventional Method.

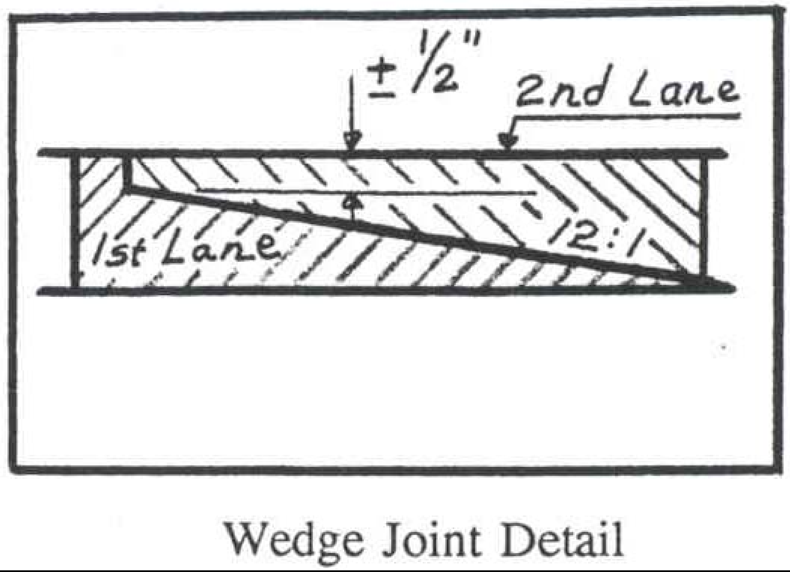


(WisDOT, 1993)

Wedge Joint Method -

The wedge joint design aims to reduce the density gradient across the joint by using two overlapping wedges to form the joint. An adjustable shoe attached to the end of the paver screed is used to form the wedge with a ½ inch notch and a 12:1 taper ratio (see Figure 3 on the following page) (WisDOT, 1993). A tack coat is applied to the first lane wedge before the second lane wedge is placed to prevent the ingress of water and to obtain good adhesion (Kandhal & Rao, 1994).

Figure 3. Wedge Joint Method.

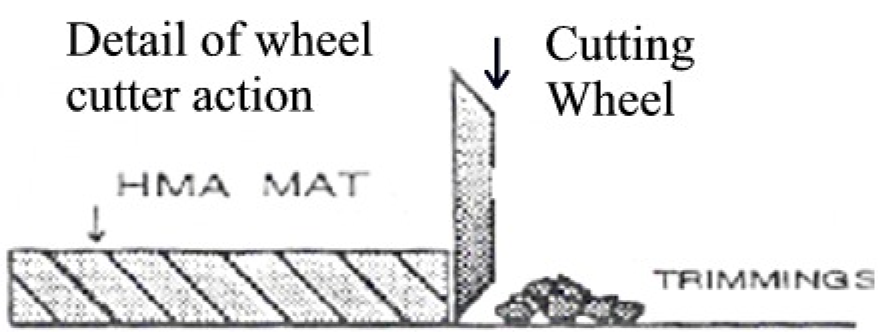


(WisDOT, 1993)

Cut Joint Method -

This joint method addresses the unconfined, low-density edge of the first (cold) lane by removing the edge altogether. While the HMA is still in a plastic state, approximately 2 inches of the unsupported edge of the compacted first lane is cut away (see Figure 4 below) (WisDOT, 1993). A tack coat is then applied to the vertical face of the cut edge and the second (hot) lane is placed. Although the densities of both lanes are more uniform, causing the density gradient to be lower, this method does not significantly improve the tensile strength across the joint (Kandhal & Rao, 1994).

Figure 4. Cut Joint Method.

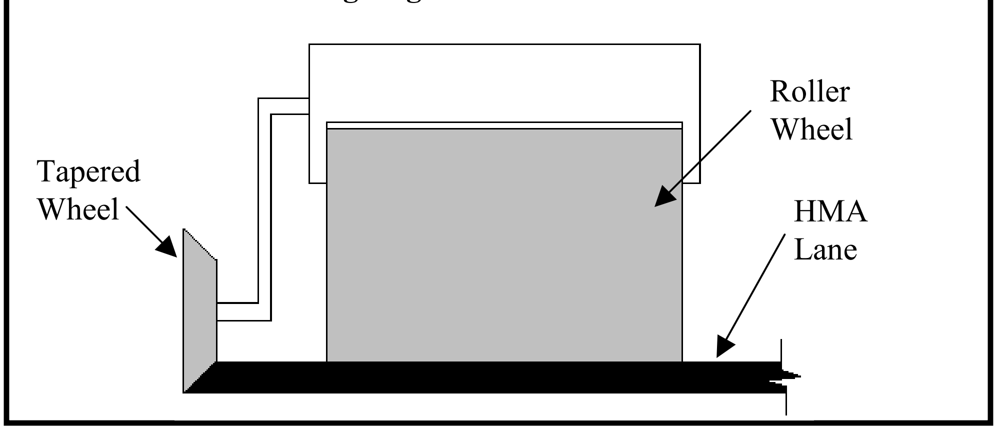


(WisDOT, 1993)

Conventional Joint with Bomag Edge Constraint Device -

The Bomag edge constraint device increases the density of the unconfined edge of the first lane through the use of a hydraulically powered tapered wheel (see Figure 5 below) (Kandhal & Rao, 1994). As the first (cold) lane is compacted, the tapered wheel mounted at the end of the compacting device restrains the edge of the HMA, limiting the mat “creep” (WisDOT, 1993). The vertical plane formed at the mat edge is coated with tack and then the second lane is placed.

Figure 5. Conventional Joint with Bomag Edge Constraint Device.



(Kandhal & Rao, 1994)

TEST SECTIONS

In September of 1993, eight test sections were constructed on United States Highway (USH) 61 from Boscobel to Soldiers Grove in Crawford County as part of a resurfacing project (see Figures 6 and 7, pages 7 and 8). USH 61 is a 2-lane, rural highway consisting of asphaltic pavement over a crushed aggregate base course (CABC) and a granular subbase course. For this resurfacing project, the asphaltic pavement was milled in place and a new asphaltic surface was paved. The new pavement structure consists of 4 ½ in. of asphaltic pavement, paved in two lifts, over 4 in. of milled in place asphaltic base course, 7-9 in. of CABC, and 12 in. of granular subbase.

Figure 6. Longitudinal Joint Construction Project Location.

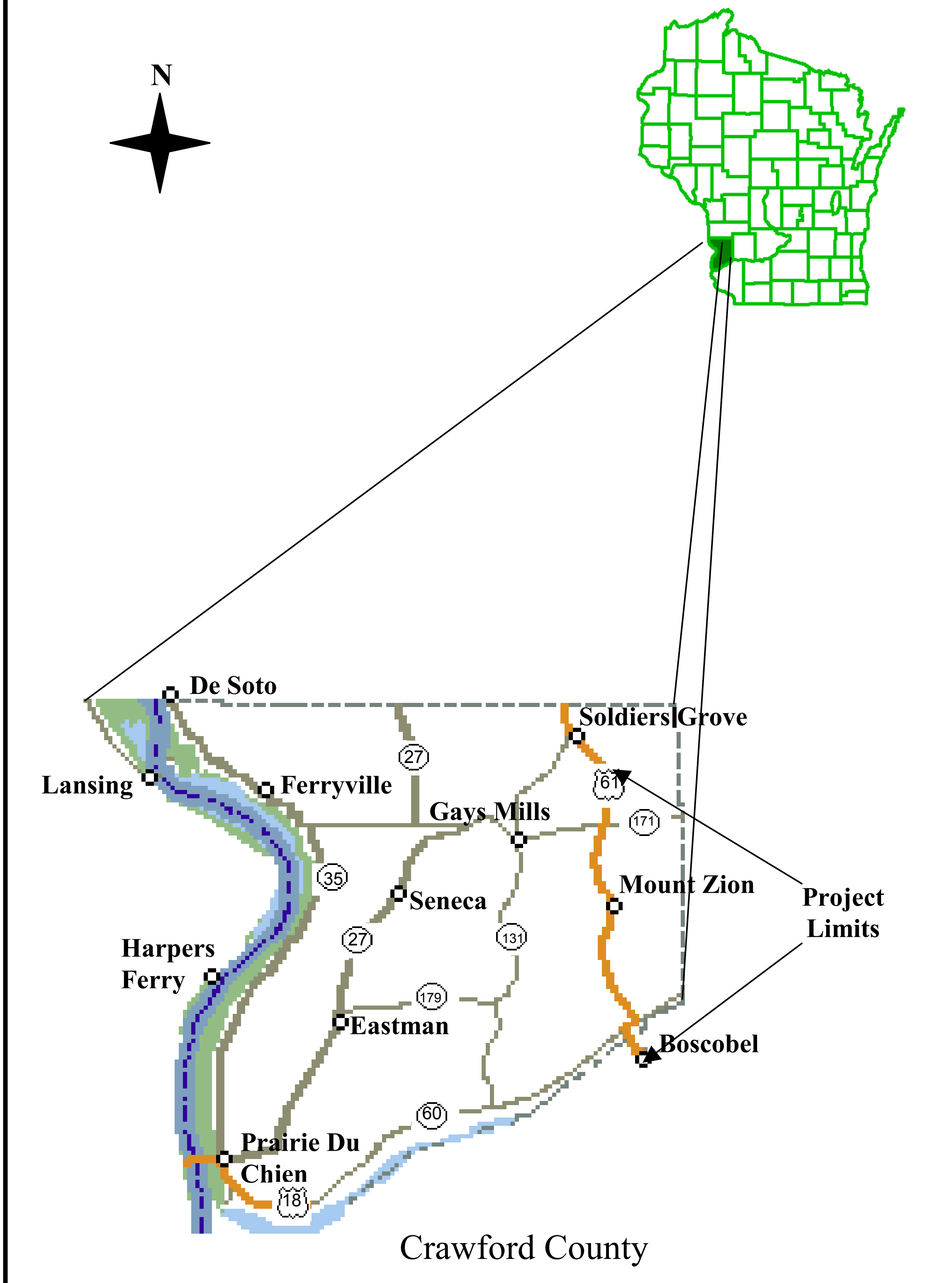
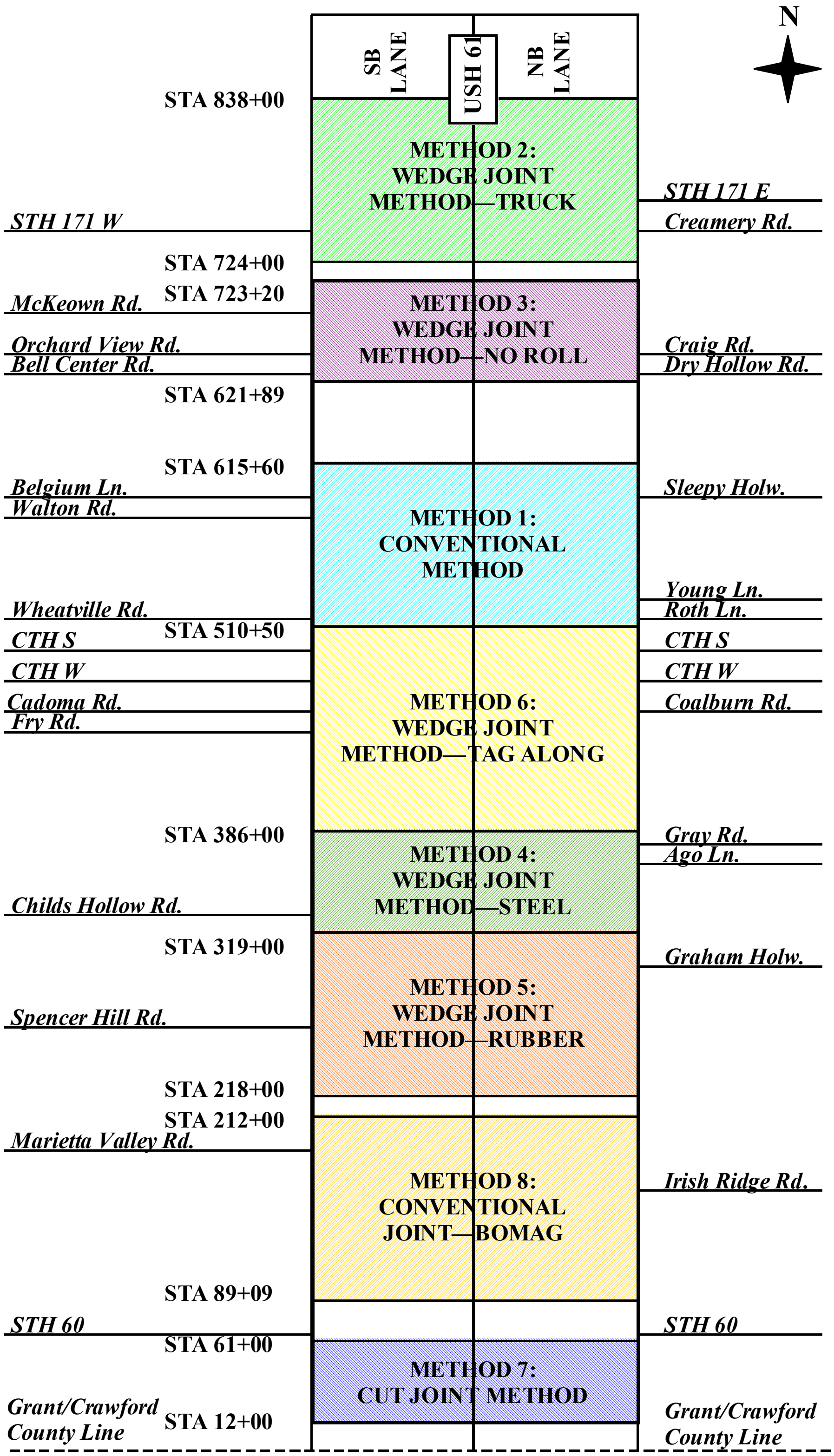


Figure 7. Longitudinal Joint Construction Test Section Layout. (Not to Scale)



Mathy Construction Company compiled the following advantages and disadvantages of each longitudinal joint construction technique during the construction of the test sections on USH 61 (Marks & Reinke, 1993):

<u>TEST METHOD 1 STA 510+50 TO STA 615+60</u>

CONVENTIONAL METHOD

<u>Advantages:</u>

- This is a well-established construction technique; no changes were required.

<u>Disadvantages:</u>

- The densities in the joint area were lower than those in the surrounding mat.
- This method has a history of raveling, beginning at the joint.

<u>TEST METHOD 2 STA 724+00 TO STA 838+00</u>

WEDGE JOINT METHOD (ROLLING WITH HAULING TRUCK TIRES)

<u>Advantages:</u>

- This is an easy method of compaction for the wedge joint.
- This method is able to apply more effective weight to the narrow [tapered] strip of HMA.

<u>Disadvantages:</u>

- Occasionally, the trucks forgot to roll the joint. A more consistent pattern was maintained once designated rolling trucks were assigned to roll the joint.
- The truck tires had a tendency to throw mix aggregates onto the new HMA mat.
- There was the potential for the trucks to scuff the edge of the mat during the rolling operation.
- The rolling trucks do not or cannot remain completely on the joint all the time, creating a potential for inconsistent rolling.

TEST METHOD 3 STA 621+89 TO STA 723+20

WEDGE JOINT METHOD (NO ROLLING)

Advantages:

- The joint is well formed in most cases – The porous, unrolled wedge accepted the top overlay very well during rolling because the larger aggregate in the thin part of the overlay wasn't constrained by the solid underlayment. This prevented the vibratory roller from "riding" the edge of the joint.
- There were no protrusions [or attachments] on the rollers.

Disadvantages:

- There is a potential for lower densities on the centerline due to inadequate compaction of the bottom taper.

TEST METHOD 4 STA 319+00 TO STA 386+00

WEDGE JOINT METHOD (ROLLING WITH STEEL SIDE ROLLER WHEEL)

Advantages:

- The steel roller is able to achieve consistent rolling pressure on the joint.
- The roller contributed to a much better formation of the ½-inch notch.
- From a production standpoint, it was not a problem to attach the steel roller assembly to the paver.
- The roller was able to compact the tapered area before significant cooling could occur. This operation was conducted without a spray bar on the roller, but the addition of a spray bar would improve the ease of operation of this method.

Disadvantages:

- Some additional setup and takedown time is necessary for the roller placement, but this was not a significant problem.

TEST METHOD 5 STA 218+00 TO STA 319+00

WEDGE JOINT METHOD (ROLLING WITH RUBBER SIDE ROLLER WHEEL)

Advantages:

- The operator had good visibility of the roller to maintain proper position of the wedge compaction tires.

Disadvantages:

- The hydraulic down-pressure capability on the small roller makes it possible for varying degrees of wedge compaction, depending on pressure applied by the operator when starting a pass.

TEST METHOD 6 STA 386+00 TO STA 510+50

WEDGE JOINT METHOD (ROLLING WITH TAG-ALONG ROLLER)

Advantages:

- This method was able to apply hydraulic pressure on the taper compaction roller.

Disadvantages:

- It was difficult for the operator to see the small steel tag-along roller while maintaining the proper paver position on the HMA mat.
- The hydraulic down-pressure made it possible for the operator to get too much pressure on the wedge, relative to the mat, affecting compaction under the paver.

TEST METHOD 7 STA 12+00 TO STA 61+00

CUT JOINT METHOD

Advantages:

- This method removes the portion of the first mat with the lowest density before the second [lane] is paved.

Disadvantages:

- This process is very messy as the cutting wheel throws material out and necessitates brooming before the second lane is paved.
- It is nearly impossible to maintain a straight cutting line and a wavy and unattractive joint results.
- This method involves a lot of machinery and slows down the paving process.

TEST METHOD 8 STA 89+09 TO STA 212+00

CONVENTIONAL JOINT WITH BOMAG EDGE CONSTRAINT DEVICE

Advantages:

- This method produces a fairly consistent edge.

Disadvantages:

- It is difficult for the operator to see the constrictor, making it difficult for the operator to line up to roll the joint.
- It is difficult to maintain the exact position desired for seating the joint.
- Any deviation from the edge line leaves debris in the opposite lane that must be removed before the second mat is placed.

It was also noted that, in general, modifying the paver to create a wedge joint was not difficult and required very little time to incorporate it into the operation. Also, during construction, when only one lane has been paved, the tapered edge on the open wedge joint (as opposed to the vertical step-off created by the other joints) improves safety to traffic crossing over it.

PERFORMANCE EVALUATION

Density Test Results (Taken at Time of Construction) -

Density readings were taken at the project site, using a Troxler nuclear density gauge, and in the lab from cut core samples, using the Marshall Test procedure in accordance with AASHTO T 166-00. Seven equally spaced locations within each test section were evaluated for density readings. The nuclear density readings were taken at the centerline joint, 1 ft away from the joint on both sides, and 5 ft away from the joint on both sides at all seven locations for each test section. The cores cut for the laboratory density testing were taken from the centerline joint and 1 ft away from the joint on both sides at all seven locations for each test section, as close as possible to where the nuclear density readings were taken. The results from the nuclear and laboratory density testing are listed in Tables 1 and 2 (page 13).

Table 1. Nuclear Density Readings.

Test Method	Longitudinal Joint Construction Technique	Troxler Nuclear Density Gauge Readings (lb/ft^3)				
		Hot Lane		Centerline	Cold Lane	
		5' off CL	1' off CL	Joint	1' off CL	5' off CL
1	Conventional	137.77	137.13	136.46	135.56	137.81
2	Wedge compacted with hauling truck	139.06	138.74	138.34	137.93	140.21
3	Wedge with no compaction	140.83	140.09	139.43	138.97	140.79
4	Wedge with steel wheel side roller on side of steel wheel roller	143.70	140.69	138.47	139.26	140.13
5	Wedge with rubber side roller on side of rubber tire roller	139.97	138.99	137.94	136.77	138.67
6	Wedge with tag along roller on HMA paver	141.34	139.40	138.30	139.61	139.97
7	Cut joint method with the edge of the mat milled	141.47	142.30	135.06	136.99	140.29
8	Conventional with Bomag edge constraint device	140.99	137.91	139.10	139.24	139.37

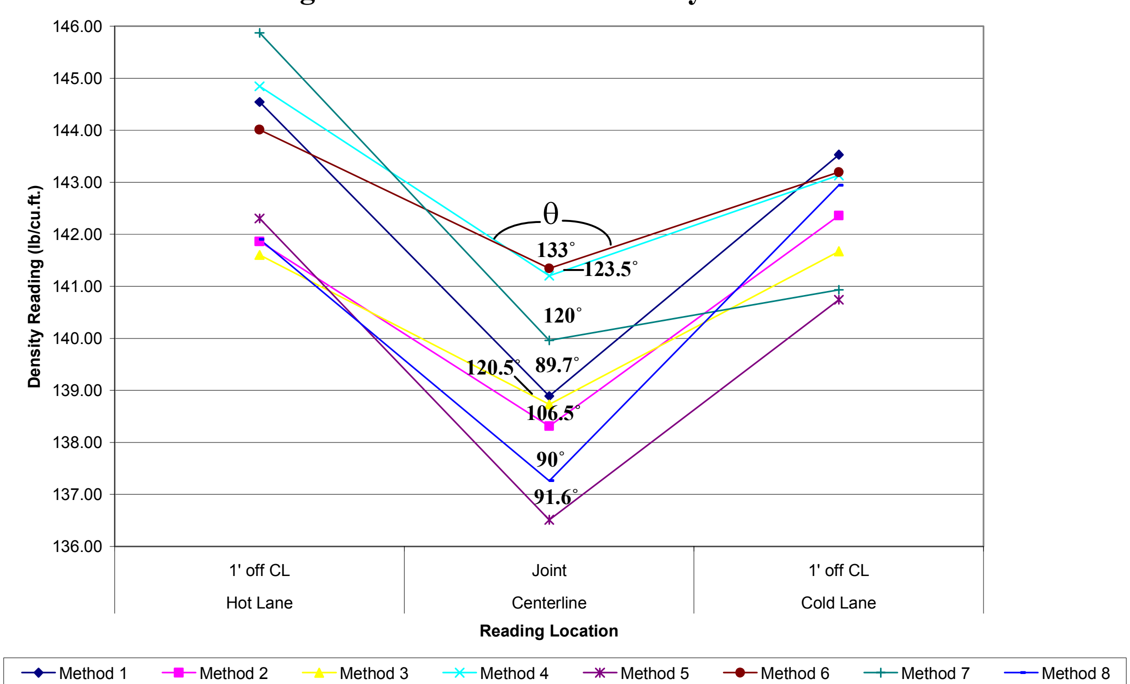
Table 2. Laboratory Density Readings.

Test Method	Longitudinal Joint Construction Technique	Lab Density Readings (lb/ft^3) (Marshall Test Procedure)		
		Hot Lane 1' off CL	Centerline Joint	Cold Lane 1' off CL
1	Conventional	144.54	138.89	143.53
2	Wedge compacted with hauling truck	141.86	138.31	142.36
3	Wedge with no compaction	141.60	138.73	141.67
4	Wedge with steel wheel side roller on side of steel wheel roller	144.84	141.20	143.13
5	Wedge with rubber side roller on side of rubber tire roller	142.30	136.51	140.74
6	Wedge with tag along roller on HMA paver	144.01	141.34	143.19
7	Cut joint method with the edge of the mat milled	145.87	139.96	140.93
8	Conventional with Bomag edge constraint device	141.90	137.26	142.94

Upon comparison of Tables 1 and 2, it is clear that there is a lack of correlation between the nuclear density data and the density data from the Marshall lab testing. To check the accuracy of the Troxler nuclear density gauge, WisDOT used a Seamans nuclear density gauge to collect density readings from the locations where the cores were taken. It was found that the density results from the WisDOT nuclear density gauge (see Appendix A, page 22) were not similar to the Troxler results or the lab results. These discrepancies may be due in part to the fact that the contractor's Troxler nuclear density gauge and WisDOT's Seamans nuclear density guage were not calibrated using the same test blocks. Based on these findings, it was decided that the laboratory density results from the Marshall Test procedure are likely to be the most accurate for this study.

The laboratory density results are graphed in Figure 8 below. The angle between the density points for each test method will be referred to as θ. When θ=180˚, or the points form a horizontal line, the pavement does not have a density gradient. All joint construction techniques produced a density gradient across the centerline joint, but those with θ closer to 180˚ have smaller gradients. Methods 6 and 4 show the smallest density gradients with θ=133˚ and θ=123.5˚, respectively.

Figure 8. Marshall Test Density Results.



WisDOT specifications require the HMA pavement used in the upper layer of a high volume traffic lane to be compacted to 92 percent of its maximum density. Maximum density of an HMA mix is determined by multiplying the HMA mixture's maximum specific gravity (2.461 in this study) by the unit weight of water (62.24 lb/ft^3). The HMA evaluated in this study has a target maximum density of 153.17 lb/ft^3. Using the lab density results from the cores, the percentages of maximum density for each joint construction technique are shown in Table 3 below. The shaded values in the table represent maximum density percentages that fall below 92 percent and therefore, do not meet WisDOT specifications. Only two joint construction methods have acceptable densities:

- Wedge with steel wheel side roller on side of steel wheel roller (Method 4) and
- Wedge with tag-along roller on HMA paver (Method 6).

Table 3. Percent of Maximum Density.
(Based on Lab Density Readings)

Test Method	Longitudinal Joint Construction Technique	Percent of Maximum Density (%) (Marshall Test Procedure) Hot Lane 1' off CL	Centerline Joint	Cold Lane 1' off CL
1	Conventional	94.37	90.68	93.71
2	Wedge compacted with hauling truck	92.62	90.30	92.94
3	Wedge with no compaction	92.45	90.57	92.49
4	Wedge with steel wheel side roller on side of steel wheel roller	94.56	92.19	93.45
5	Wedge with rubber side roller on side of rubber tire roller	92.90	89.12	91.88
6	Wedge with tag along roller on HMA paver	94.02	92.28	93.48
7	Cut joint method with the edge of the mat milled	95.23	91.38	92.01
8	Conventional with Bomag edge constraint device	92.64	89.61	93.32

Note: Percentages less than 92 percent are shaded. These densities do not meet WisDOT specifications.

Density data was also used to evaluate the density gradient across the longitudinal joint. Table 4 below shows the longitudinal joint (centerline) density as a percentage of the densities of the adjacent lanes. Although WisDOT does not have any specifications pertaining to this data, some researchers suggest that the density at the longitudinal joint should not be more than 2 to 3 percent lower than the density of the adjacent lanes (Fleckenstein, Allen, & Schultz, 2002; Kandhal, 1998).

Table 4. Percent of Adjacent Lane Densities.
(Based on Lab Density Readings)

Test Method	Longitudinal Joint Construction Technique	Percent of Adj. Lane Densities (%) (Marshall Test Procedure)	
		CL Density as a Percentage of Hot Lane Density	CL Density as a Percentage of Cold Lane Density
1	Conventional	96.09 *4% lower*	96.77 *3% lower*
2	Wedge compacted with hauling truck	97.50 *2% lower*	97.16 *3% lower*
3	Wedge with no compaction	97.97 *2% lower*	97.92 *2% lower*
4	Wedge with steel wheel side roller on side of steel wheel roller	97.49 *3% lower*	98.65 *1% lower*
5	Wedge with rubber side roller on side of rubber tire roller	95.93 *4% lower*	96.99 *3% lower*
6	Wedge with tag along roller on HMA paver	98.15 *2% lower*	98.71 *1% lower*
7	Cut joint method with the edge of the mat milled	95.95 *4% lower*	99.31 *0% lower*
8	Conventional with Bomag edge constraint device	96.73 *3% lower*	96.03 *4% lower*

Overall Performance Ranking -

Performance ranking of the test sections was based on the amount of longitudinal cracking developing from the longitudinal joint. The final performance evaluation, conducted in the summer of 2003, found that after ten years, the wedge joint construction technique performed better than all of the other joint construction techniques. As shown in Table 5 on the following page, the tag-along roller (Method 6) created the best wedge joints, followed by the steel wheel side roller (Method 4). However, based on the workers' comments, it is much easier to construct a wedge joint using a steel wheel side roller than the tag-along roller. The wedge joint constructed by the steel wheel side roller is also the only technique to consistently rank in the top three best performers in all of the performance evaluations (see Appendix B, page 23).

Table 5. 10-Year Performance Evaluation (Listed in Order of Cracking Percentage)

Test Method	Longitudinal Joint Construction Technique	Percent of Longitudinal Joint Cracking (%)
6	Wedge with tag along roller on HMA paver	21
4	Wedge with steel wheel side roller on side of steel wheel roller	33
3	Wedge with no compaction	46
2	Wedge compacted with hauling truck	62
5	Wedge with rubber side roller on side of rubber tire roller	69
1	Conventional	86
8	Conventional with Bomag edge constraint device	94
7	Cut joint method with the edge of the mat milled	100

RESULTS

Based on the percentage of maximum density results, the wedge with steel wheel side roller on side of steel wheel roller (Method 4) and the wedge with tag-along roller on HMA paver (Method 6) both achieved acceptable levels of compaction according to WisDOT specifications. The centerline density was no more than 3 percent lower than the adjacent lane densities for both Method 6 and Method 4. These two methods also showed the lowest density gradients when graphed. Additionally, the overall performance ranking showed that Method 6 and Method 4 produce the best performing longitudinal joints.

CONCLUSIONS

The NCAT/Auburn study concluded that the cut joint and constrained edge joint performed best in the Wisconsin project, followed by the wedge joint (Kandhal & Rao, 1993). Upon the completion of this WisDOT study (# 93-08), it has been found that the wedge joint performs better than the cut joint and the constrained edge joint. The results show that the wedge joint in Wisconsin, when constructed with better equipment and by more experienced workers, performs as well as it does in Michigan.

From the constructability standpoint, the wedge joint creates less debris and can be constructed more efficiently than the cut joint and the constrained edge joint. The wedge joint is also significantly safer for traffic, as the transition from the newly paved lane to the unpaved lane is tapered instead of a vertical step-off like the other joint methods produce. The results of this study have found that the tag-along roller and the steel wheel side roller compaction techniques both produce acceptable wedge joints. However, since it is often difficult for the paver operator to see the tag-along roller, the steel roller is preferred for compacting the wedge joint.

Due to the success of the wedge joint in other states, WisDOT created a Special Provision Specification for Longitudinal [Wedge] Joints of Asphaltic Pavements in 1994 (see Appendix C, page 25) to be used at the option of the contractor. With increased experience and better equipment, the success of the wedge joint in Wisconsin has grown steadily and it is now constructed by many of the state's contractors.

RECOMMENDATIONS

It is recommended that:

- The WisDOT Technology Advancement Unit (TAU) conduct more research to determine if the wedge joint compacted with a steel roller will perform well over various subgrades or as an overlay over various pavement materials.
- The WisDOT TAU investigate whether or not compaction levels at the longitudinal joint can be determined using a nuclear density gauge. Tom Brokaw, of the WisDOT Quality Management section, has stated that the overall

variability/repeatability of the nuclear density gauge is a concern. It has also been reported that seating problems on the longitudinal joint may cause the nuclear density readings to be inaccurate (Kandhal, Ramirez, & Ingram, 2002).

- The WisDOT Quality Management section continue to research other methods of evaluating longitudinal joints in asphaltic pavements during construction. As stated by Tom Brokaw (WisDOT Quality Management), density information is an empirical tie to the pavement's performance; it is not a direct measurement.
- The WisDOT TAU continue to investigate the success other states are having with joint reheaters and joint adhesives. Although WisDOT does have a standard special provision (STSP) for joint reheaters (Item 460.4100S) and use of the technique has shown good results on Interstate Highway (IH) 94 in Racine County, more research is needed to determine the proper applications for the use of the joint reheater.

IMPLEMENTATION

- WisDOT TAU will make a recommendation at a Wisconsin Asphaltic Pavement Association (WAPA)/WisDOT meeting to adjust the specification to make wedge joint construction a requirement instead of an option. Any other longitudinal joint construction technique would not be permissible without the engineer's approval[2]. This would help to ensure consistent quality in joint construction work.

[2] Tom Brokaw (WisDOT Quality Management) has stated that the wedge joint is not practical for all asphalt mixtures. It would be difficult to construct the wedge joint when using some stone matrix asphalt (SMA) and other coarse asphalt mixtures. Also, some researchers have found that it is difficult to construct the wedge joint for surface mixtures with a thickness less than 1 ½ in. (Fleckenstein, Allen, & Schultz, 2002).

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APPENDIX A:

SEAMANS NUCLEAR DENSITY RESULTS (WISDOT)

Test Method	Longitudinal Joint Construction Technique	WisDOT Seamans Nuclear Density Gauge Readings (lb/ft^3)		
		Hot Lane 1' off CL	Centerline Joint	Cold Lane 1' off CL
1	Conventional	147.50	145.00	144.00
2	Wedge compacted with hauling truck	143.50	140.90	143.60
3	Wedge with no compaction	146.20	144.20	144.80
4	Wedge with steel wheel side roller on side of steel wheel roller	145.20	146.40	145.50
5	Wedge with rubber side roller on side of rubber tire roller	143.10	142.00	141.30
6	Wedge with tag along roller on HMA paver	147.30	144.80	146.00
7	Cut joint method with the edge of the mat milled	145.00	143.30	142.80
8	Conventional with Bomag edge constraint device	143.40	140.80	144.80

APPENDIX B:

OVERALL PERFORMANCE RANKINGS

Test Section	Joint Construction Technique	Performance Evaluation Rank (1 = Best)				
		2 Year	3 Year	4 Year	5 Year	10 Year
1	Conventional	8	5	6	6	6
2	Wedge compacted with hauling truck	3	6	2	5	4
3	Wedge with no compaction	6	2	3	1	3
4	Wedge with steel wheel side roller on side of steel wheel roller	2	3	1	2	2
5	Wedge with rubber side roller on side of rubber tire roller	1	4	4	3	5
6	Wedge with tag along roller on HMA paver	7	1	5	4	1
7	Cut joint method with the edge of the mat milled	5	7	8	7	8
8	Conventional with Bomag edge constraint device	4	8	7	8	7

APPENDIX C:

SPECIAL PROVISION SPECIFICATION FOR LONGITUDINAL [WEDGE] JOINTS OF ASPHALTIC PAVEMENTS

Bob Schmiedlin

CORRESPONDENCE/MEMORANDUM STATE OF WISCONSIN

DATE: May 9, 1994

TO: District Chief Construction Engineers
District Chief Construction & Materials Engineers
District Chief Materials Engineers
District Materials Supervisors

FROM: Gary C. Whited, P.E.
Director, Office of Construction

SUBJECT: Implementation of Special Provision Specification for Longitudinal Joints of Asphaltic Pavements.
WisDOT Research Study No. 93-08

WisDOT and the Wisconsin asphalt paving industry jointly have developed a special provision specification for use of an optional longitudinal joint for asphaltic pavements. A copy of the specification is attached. Incorporation of this specification into a project will be by contract change order. Use of this specification is at the option of the contractor and no additional costs shall result to the Department.

This specification is intended to be developmental and experimental for use in the 1994 construction season. Intentionally, this is not written as a methods specification. Therefore, details are not included for: mat thickness limits, tilting screed construction, use over CABC, brooming and racking, cold weather limitations, etc. However, construction practices used by the contractor shall result in quality joints according to the approval of the project engineer. Especially, compaction of the joint shall be emphasized to better ensure satisfactory performance.

Each district is asked to maintain a record of projects on which the optional joint is constructed. The record shall include sufficient information to permit monitoring performance of the joints by future inspections. District personnel are advised to record pertinent construction information related to the optional joint work for examination and review later.

At this time, it appears a meeting to critique the optional joint work done by early fall might be appropriate. 1994 experiences will be used to determine revisions to the specification and help to establish if and when a change in the standard joint specification is appropriate.

Your comments concerning this specification are welcome. Contact [redacted], [redacted] for information on this material.

GCW:m00238

Attachment

cc: Gary Whited
Bill Bauer
Gerry Burns
Dave Jensen
John Pope
Johnny Gerbitz
Joe McKee
Jerry Waelti
Julie Neebel
Bob Schmiedlin
Steve Shober
Tom Brokaw
John Volker
Pat Fleming

WISCONSIN DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS

SPECIAL PROVISION SPECIFICATION
FOR
LONGITUDINAL JOINTS OF ASPHALTIC PAVEMENTS

A. Description. The work under this specification shall be in accordance with requirements of the Wisconsin Standard Specifications and as hereinafter provided.

The provision of this Article shall apply to the asphaltic mixtures included in this contract as follows: The contractor shall have the option to construct tapered, overlapping and notched longitudinal joints (in lieu of the standard longitudinal joints) for binder and surface courses of asphaltic pavement construction for HV, MV and LV mixtures when approved by the engineer.

When the quality of work performed on tapered joints is not acceptable to the engineer, the standard longitudinal joint shall be used.

The use of the optional longitudinal joint construction eliminates the requirements of the third and fourth paragraphs of Subsection 405.5.10.1 of the Standard Specifications. Adjacent lanes shall be paved (brought level) within 48 hours unless delayed by inclement weather or otherwise required by the engineer.

B. Construction Method. The optional longitudinal joint first pass shall be constructed by providing a ± 1/2 inch vertical notch at the lane joint and tapering the edge of the asphaltic material course. The taper shall have a one-inch rise over a 12-inch run and extend beyond the normal lane width or as directed by the engineer (see detail drawing). The tapers for all courses shall directly overlap and slope in the same direction. The finished longitudinal joint line of the top course shall be at the pavement centerline, if the roadway is two lanes, or at lane lines if the roadway is more than two lanes.

The tapered portion of the pavement shall be constructed with a uniform slope. Attention shall be given to compaction of the tapered portion of the joints in order to avoid ravelling or spalling problems in the future. Compaction of the taper portions shall be as near to final pavement density as practicable. A tack coat shall be applied to each course of asphaltic material and to the in-place first pass taper before the succeeding adjacent or upper layer is placed.

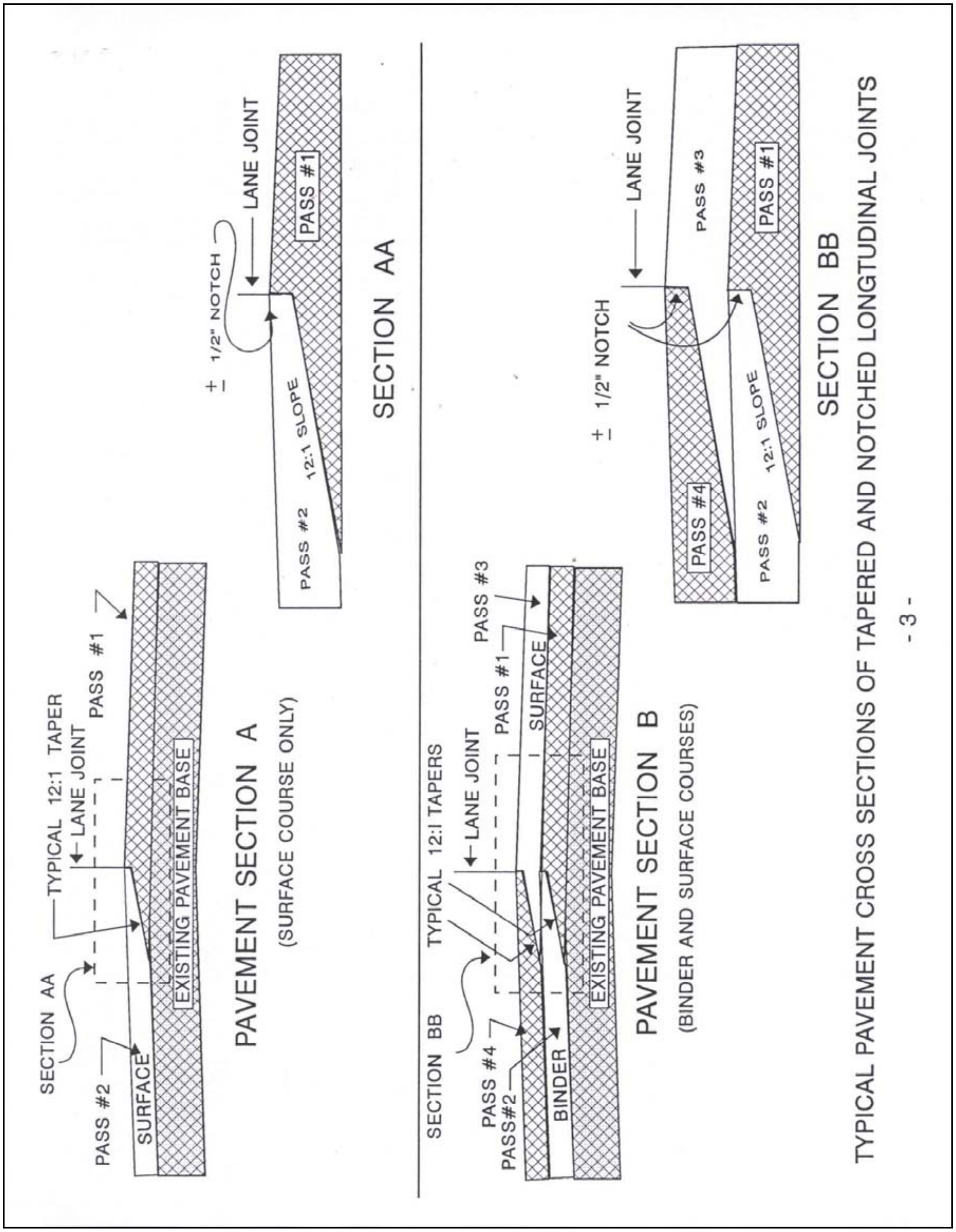
C. Traffic Control. In addition to requirements of the Wisconsin Standard Specifications, use of the optional joint shall require 48" x 48" orange diamond shaped signs with an **uneven lanes symbol** and a 36" x 24" subplaque with the **words "UNEVEN LANES"**. The signs shall be placed in advance of paving and at maximum intervals of approximately 2500 feet. The additional signing shall be in-place when the newly paved lane is open to traffic and shall remain in-place until the adjacent lane is paved.

A minimum of two uneven pavement signs shall be erected in each direction. The cost of furnishing, placing, and removing the uneven pavement signs shall be incidental to the bid cost of paving.

D. Pavement Marking. Requirements of the Wisconsin Standard Specifications shall be applicable for this work. In cases when temporary pavement marking and pavement marking, same day, is required, all marking (including no passing zone markings) shall be visible on the entire length of the project.

The cost per linear foot of pavement markings which would have been placed had the standard joint been used, rather than the optional joint, will be paid for under the appropriate pay items. all additional markings, required by construction of the optional joint, will be incidental to the cost of paving.

m00247



TYPICAL PAVEMENT CROSS SECTIONS OF TAPERED AND NOTCHED LONGTUDINAL JOINTS

- 3 -